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Feasibility of the use of the Single Exponential Smoothing method (SES) to forecast wind speed values for wind power generation to achieve sustainability in Trinidad

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ABSTRACT

The global drive for clean, sustainable, renewable energy has become the ultimate objective of most progressive countries in the world. There is an urgent need for Trinidad and Tobago to adopt the new culture of renewable energy due to the dwindling fossil fuel resources and the impact of this fuel on human development and the environment. Through investing in alternative energy, the vast problems created by the diminishing energy reserves could be minimized. Additionally, alternative energy could be the essential ingredient to promote economic growth of the country since the economy of Trinidad and Tobago depends solely on fossil fuel resources. Sustainable development is attained by meeting the present needs while at the same time, placing measures to fulfill the future needs of the country. Therefore, reliance on renewable energy sources such as wind energy, could be essential for sustainability in Trinidad and Tobago. This paper examines the viability of the Single Exponential Smoothing (SES) method to forecast wind speed values required for wind power gen The predicted average annual value of the wind speed is correlated with the actual average annual value of the wind speed for a ten year period in achieving sustainability in Trinidad and Tobago.

Keywords: clean, renewable, sustainable, energy, economy

1. INTRODUCTION

Trinidad and Tobago is a developing country which uses conventional fossil fuel resources to satisfy its energy needs. Presently, it is confronted with numerous challenges pertaining to the energy sector. There are much concerns arising because of increased carbon emissions from the conventional use of fossil fuels and the dwindling supply of these traditional valuable non renewable energy resources (Chadee, et al., 1999). Renewable energy technologies could be potential contributors to achieving sustainable development since energy is an entry point in achieving sustainable development.

In achieving sustainability, the level of consciousness about renewable energy applications has increased. Sustainability refers to the ability to meet the present needs of the country, while at the same time, being able to provide for its future needs. It is viewed as an economic entity where emphasis is placed on fostering production growth through market investments (Rajnauth, 2003). It is crucial to use renewable energy sources to drive the economy of the country. Due to the impacts of climate change and global warming, it is imperative to utilize energy sources that do not cause any environmental emissions. As such, the principal focus of this study is on the feasibility use of wind energy as a renewable energy resource in accomplishing sustainability.

Wind is an attractive, clean, indigenous energy resource in which the kinetic energy of the wind is used to produce electrical energy (Chen, et al., 1990). Therefore, the wind speed is a fundamental aspect in using wind energy. As such, it is necessary to critically analyze the wind speed at a site in the determination of the amount of energy that could be extracted from the wind at a particular location.

Wind is considered as one of the most difficult meteorological parameter to forecast. This is due to the complex interactions of the temperature and pressure differences in relation to the local characteristics of the surface (Barthelmie, 2010). The forecasting technique depends on the available information, the time period and its application.

The forecasting measure used to predict the wind speed is the Single Exponential Smoothing Technique (SES). Single Exponential Smoothing (SES) Technique is a statistical technique that could be used to forecast wind data (Cadeno et al., 2010). This is based on the intuitive application of movable averages. This technique is robust and has a fast and efficient implementation using descriptive and inferential statistics.

This paper analyses the feasibility of using the Single Exponential Smoothing method in forecasting the wind speeds for the area of Piarco, Trinidad and relates it to the use of wind energy in achieving sustainability in Trinidad.

2.0 METHODOLOGY

According to Cadeno et al., (2010), the Single Exponential Smoothing (SES) could be useful in forecasting the wind speed in an area. In forecasting, observations provide the best guide to predict the future potential a renewable energy system. Cadeno et al., (2010) applied the technique of the Single Exponential Smoothing (SES) to forecast the wind velocity in the city of Chetumal, Mexico. The analysis and forecasting of the wind speed in Chetumal is very important for predicting the wind power variations and performance of the wind turbines.

In Chetumal, Mexico measurements were taken at 10 meters above ground and the wind speed values were recorded at 10 minute intervals. These measurements were taken over a two year period. Three cone shaped anenometers were used to measure the wind speed because of its design to maintain a uniform torque throughout its revolution. Conventional wind vanes were used to measure the wind direction.

Average values for all the parameters were calculated at the ten minute intervals. However, the average for the wind direction was taken as the mean of all values and was a unit resultant value. Therefore, average values were used to report the wind speed variability. The short term variations indicate variations over a time interval for ten minutes and include variations in turbulence or gusts.

The following mathematical expressions are useful in forecasting the wind speed in an area :

F_t is the forecast at some point during the time period when the measurements were taken and Y_t is the available observations. The forecast errors are found using : $E_t = Y_t - F_t$ **eq. (1)**

The Single Exponential Smoothing takes the forecast for the previous period and adjusts it using the forecast error.

The forecast for the next period is evaluated using : $F_{t+1} = F_t + \alpha(Y_t - F_t)$ **eq. (2)**
Where α is a constant between 0 and 1.

From the above equations, the new forecast was the sum of the old forecast and the adjustment for the error that occurred in the last forecast.

Instead of applying all the possible values of α between 0 and 1, the values of α used in the forecasting are: $\alpha = 0.1$, $\alpha = 0.5$ and $\alpha = 0.9$. This values are applied for the ten year period: 2000 to 2009.

3.0 RESULTS

Table 1 : Average Monthly Wind Speed Values in Piarco, Trinidad

MONTH	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
January	2.57	3.08	3.79	2.57	2.57	1.54	2.57	3.08	3.08	1.54
February	3.08	3.79	3.08	3.79	3.08	2.06	3.08	3.08	2.57	2.57
March	3.08	3.79	3.79	3.79	3.08	3.08	3.08	3.79	4.63	2.06
April	3.79	4.11	3.08	4.11	3.08	3.08	3.08	3.79	3.08	2.57
May	3.79	4.11	3.79	4.63	3.08	2.57	3.08	3.08	3.08	3.08
June	3.79	3.79	3.79	3.79	3.08	2.06	3.08	3.79	3.08	2.57
July	2.57	2.06	3.08	2.57	2.57	1.54	2.57	3.79	3.79	2.06
August	2.06	2.06	2.57	1.03	2.06	1.54	1.54	5.14	3.08	2.06
September	2.06	2.57	2.06	1.54	1.54	1.54	4.63	4.63	5.14	2.06
October	2.06	2.57	2.06	1.54	1.54	1.54	4.11	4.11	5.65	2.57
November	2.06	2.06	2.57	1.54	1.54	1.54	4.11	3.08	3.79	2.57
December	3.08	2.57	3.08	2.06	1.54	2.06	3.79	3.79	4.11	3.08

Table 2 : Predicted Average Annual Wind Speed Values Using α = 0.1
Applying Equation (2) using α = 0.1

Year	Average Annual Wind Speed (m/s)	Predicted Annual Wind Speed (m/s)	Difference between average value and predicted value of the wind speed
2001	3.05	2.85	0.20
2002	3.06	2.87	0.19
2003	2.75	2.86	0.11
2004	2.40	2.81	0.41
2005	2.01	2.73	0.72
2006	3.23	2.92	0.31
2007	3.76	3.00	0.76
2008	3.76	3.08	0.68
2009	2.40	3.15	0.75

Table 3: Predicted Average Annual Wind Speed Values Using α = 0.5
Applying equation (2) using α = 0.5

Year	Average Annual Wind Speed (m/s)	Predicted Annual Wind Speed (m/s)	Difference between the actual value and the predicted value of the wind speed
2001	3.05	2.94	0.11
2002	3.06	3.00	0.06
2003	2.75	2.88	0.13
2004	2.40	2.64	0.24
2005	2.01	2.32	0.31
2006	3.23	2.78	0.45
2007	3.76	3.27	0.49
2008	3.76	3.52	0.24
2009	2.40	4.08	1.68

Table 4: Predicted Average Annual Wind Speed Values α = 0.9
Applying Equation (2) using α = 0.9

Year	Average Annual Wind Speed (m/s)	Predicted Annual Wind Speed(m/s)	Difference between the actual value and the predicted value of the wind speed
2001	3.05	3.03	0.02
2002	3.06	3.06	0.00
2003	2.75	2.78	0.03
2004	2.40	2.44	0.04
2005	2.01	2.05	0.04
2006	3.23	3.11	0.12
2007	3.76	3.70	0.06
2008	3.76	3.75	0.01
2009	2.40	4.97	2.57

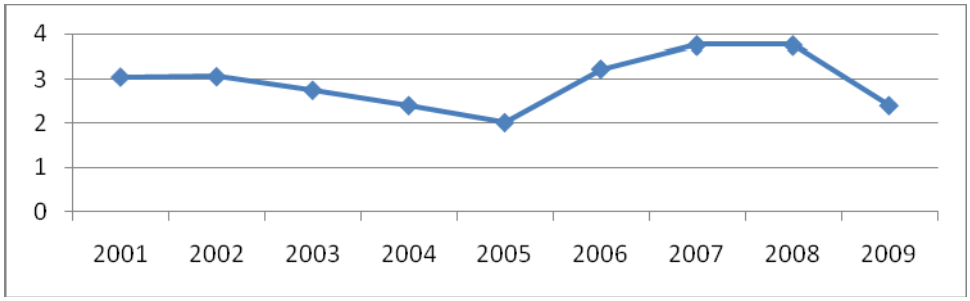

Figure 1 : Average Annual Wind Speed against the Year for Piarco, Trinidad

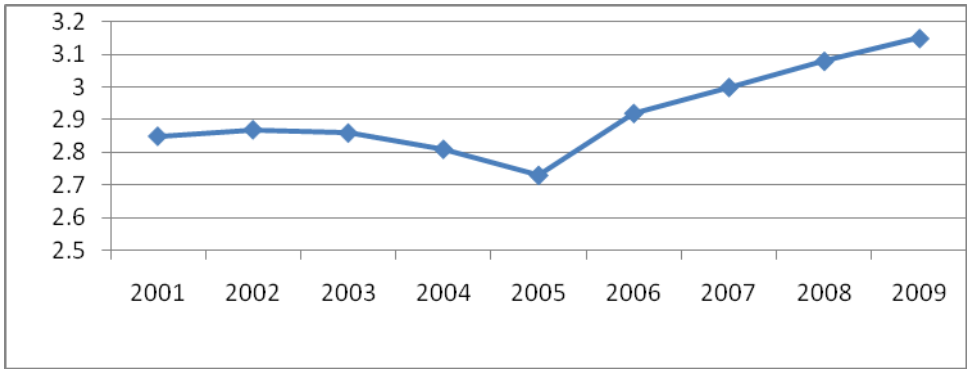

Figure 2: Predicted Annual Wind Speed against Year for α = 0.1

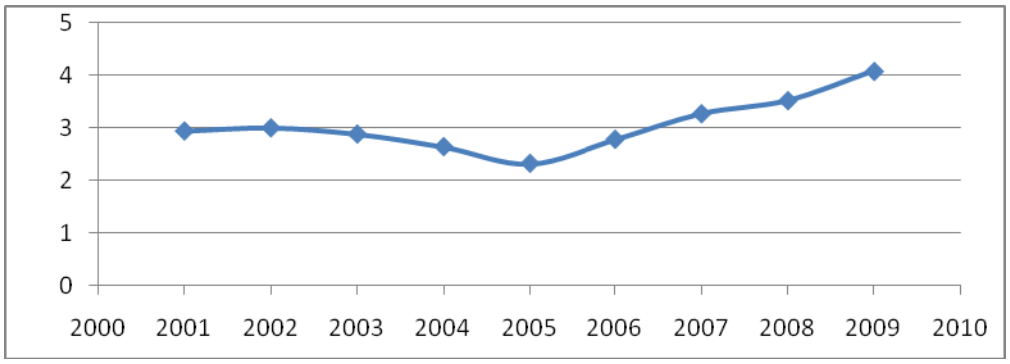

Figure 3: Predicted Annual Wind Speed against Year for α = 0.5

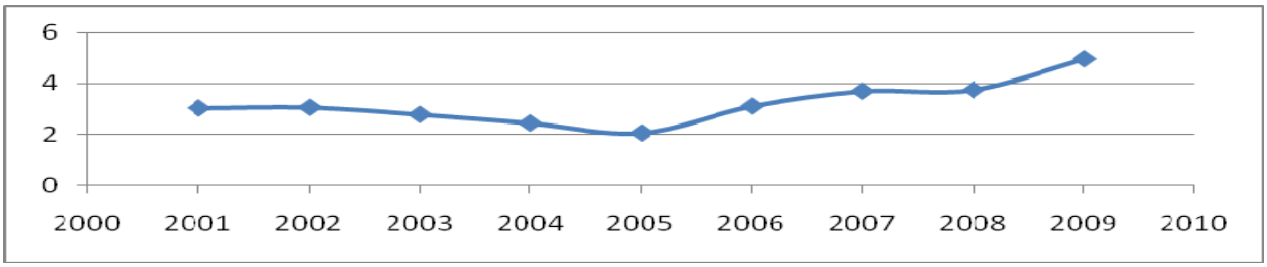

Figure 4: Predicted Annual Wind Speed against Year for α = 0.9

4.0 DISCUSSION

By promoting sustainable development through the use of wind energy, present and future data on wind energy are necessary. Hence, a reasonable estimate of the potential of wind energy is required. The wind speed is the most important parameter that is considered in the use of wind energy. By conducting the data analysis, the necessary deviations between the actual annual average wind speed and the predicted annual average speed were observed. Since the deviations were less than 1.0 m/s and the predicted annual average wind speed was less than the actual average wind speed in most cases, it could be reasonable to apply the Single Exponential Smoothing (SES) to evaluate the wind speed potential at a site. This is because the wind speed would not be overestimated but an average estimate would be obtained in facilitating sustainability in the island.

In the study conducted by Cadeno et al., (2010), there were minor deviations between the exact values recorded by the anenometers and the calculated values using the Single Exponential Smoothing (SES) method.

A limitation associated with the application of the Single Exponential Smoothing (SES) technique in Piarco, Trinidad could be the drastic changes in the wind speed pattern in the area of Piarco. This may cause significant errors in the forecasting technique used. According to Table One, the actual average annual wind speed values in Piarco is within the range of 2.01m/s and 3.76m/s for the ten year period. This range is very reasonable in which to apply the Single Exponential Smoothing (SES) technique since the difference between the highest and the lowest wind speed value is 1.75m/s for the ten year period.

Even though wind energy could be used as a renewable energy resource in the energy sector to facilitate sustainable development in Trinidad, there are issues relating to the integration of renewable resources into the country's economy. These issues are linked to the lack of renewable energy policies, infrastructure and investments needed to accommodate the use to renewable energy technologies such as wind energy (Francis et al., 2007). There are significant challenges that are experienced in the implementation of renewable energy technologies. One such challenge is the lack of the renewable energy policies established by the Government for the implementation of the renewable energy technologies. This has prevented further actions to be taken by the Government in the formation of renewable energy policies.

The use of renewable energy sources require significant forms of investment. As such, Government interventions are needed in the implementation process to promote sustained markets for renewable energy technologies.

The step that could be taken towards the development of the required policies is the fostering of programmes and projects by the Government in the formulation of policies (Haracksingh, 2001). According to Rajnauth (2003), in order to stimulate this development, a renewable energy committee needs to be appointed by the Government to formulate policies needed to guide future development of renewable energy.

This could be done by:

1. Changing the laws, standards and regulations. This could incorporate a systematic approach to goals and objectives in terms of the environmental, social and economic dimensions.
2. Formulating objectives and strategies for sustainable development through conducting research that reveal the technical and organizational barriers that hinder the continuity of sustainable energy initiatives.
3. Promoting research and development, international cooperation, technology transfer and standards in renewable energy technologies.

5.0 CONCLUSION

Renewable energy technologies could be potential contributors to achieving sustainable development since energy is an entry point for sustainability. As such, the future predictions on the viability of renewable energy developments are compulsory for the growth of the economy. The future predictions of wind energy could be made by the use of the Single Exponential Smoothing (SES) forecasting technique. The feasibility of this approach was determined by performing a statistical analysis on the existing wind speed values for a ten year period. Since this is a mathematical approach adopted to describe the patterns in the wind speed, there were distinct differences between the actual wind speed values and the predicted values for the ten year period. However, the magnitude of the differences depended on the values of α used. From this study, the deviations between the actual average annual wind speed and the predicted average annual wind speed ranged between 0m/s and 1m/s except for the year 2009. Additionally, from the statistical analysis conducted, the actual average annual wind speed value was higher than the predicted average annual wind speed value in most cases.This statistical technique produced a reasonable estimate of the wind speed variations that is needed in the determination of the wind energy potential at a site. Certainly, the Government officials should establish renewable energy committees to formulate the necessary policies required to facilitate the use of wind energy in Trinidad.

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